

# Legislative requirements related to substrate depth as a barrier to the construction of green roofs in Bulgaria

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## Abstract

There are 265 municipalities in Bulgaria. According to the national legislation, each Municipal Council adopts an Ordinance for the construction and protection of the green system. Most of the municipalities have such ordinances, however, only 75 of them stipulate regulative requirements, under which a green roof can be considered a green area. These requirements refer to the substrate depth and are unreasonably high. While positive impacts are reported in green roofs with a substrate layer thickness of 4 – 5 cm, green roofs with substrate depth under 10 cm are not considered a green area in any of the reviewed ordinances. One municipality considers green roofs with substrate 10-30 cm as a green area, under specific conditions. This paper provides a review of the stipulations of the Bulgarian local legislation against the existing data for the effects of green roofs with different substrate depths and outlines the need for amendment of the legislation and future research.

## Keywords

efficiency, green roofs, regional legislation, substrate depth

## Introduction

Green roofs have many social, economic and environmental benefits that positively contribute to regulating climate change, preventing floods, increasing green spaces

in urban areas and protecting biodiversity (Francis, Jensen, 2017; Dong, 2020). That is why they are becoming increasingly popular worldwide. The benefits of green roofs to restore ecosystem services are quite well established and need to be widely and appropriately distributed to perform efficiently at larger scales (Versini et al., 2020).

In Bulgaria, green roofs and green walls have been the subject of scientific interest for decades (Kisova, 1986; Kouneva, 2011, etc.). Studies have analysed the substrates (Kuneva, Yancheva, 2005), the suitable plant species (Kouneva et al., 2014), the potential of the roofs for vegetable production (Bichev, Yordanova, 2018), the applicable incentives (Guergova, Tasheva-Petrova, 2019), the relevant legislation (Kouneva, Kovachev, 2011), etc. However, green roofs are still isolated cases in the country due to some limitations. According to the requirements of the Spatial Development Act (2011), each Municipal Council adopts an Ordinance for the construction and protection of the green system on the territory of the municipality. There are 265 municipalities in the country. Most of them (about 70%) have issued such ordinances. However, the construction of green roofs is not addressed sufficiently in the local legislation and only half of the existing ordinances include regulations in this regard. Most of these ordinances stipulate unreasonably high requirements regarding the depth of the substrate (in the ordinances is used the term "soil"), which may coercion the investors to forgo the construction of green roofs.

The aim of this paper is to review the stipulations of the Bulgarian local legislation against the existing data for the effects of green roofs with different substrate depths and to outline the need for amendment of the legislation and future research on this topic.

## Methods

In March 2020, an application for access to public information under the Access to Public Information Act (2000) was sent to all 265 municipalities in Bulgaria, requesting the provision of the current Ordinances for the construction and protection of the green system. The ordinances available on the municipalities' websites were reviewed. The information was analysed for all municipalities on the territory of Bulgaria. All available ordinances were reviewed in terms of the included information/ regulations regarding the depths of the green roofs' substrate.

In addition, the scientific literature related to the depth of the substrates was reviewed. Based on a comparison of the legislative requirements, technical characteristics and proven positive effects of roofs with different depths, the need for amendment of the legislation and future research was outlined.

## Results and discussion

A total of 80 municipalities in Bulgaria do not have an Ordinance for the construction and protection of the green system. For 14 municipalities there is information that such an ordinance has been adopted, but we have not been able to access it. From the 171 ordinances available for review, in 82 were included some stipulations regarding green roofs, and in 75 were set out certain requirements, mainly related to the substrate depth, under which the green roofs can be included in the total green space of a property and multiplication coefficients for the area, depending on the depth.

The depth of the substrate, the multiplication coefficients for each depth and the number of municipalities with a certain requirement for depth/ coefficient are summarised in Table 1.

**Table I.** Number of municipalities with a certain requirement to the depths/ multiplication coefficients in regards to substrate depth of green roofs.

Depth Coefficient	10-30 cm	30-60 cm	60 cm
1	-	1	74
0.8	-	70	-
0.4	-	1	-
0.3	1	-	-

The green roofs participate in the green area of a property multiplied by a certain coefficient, depending on the thickness of the substrate. In 74 out of the analysed 75 ordinances, only green roofs with soil layer more than 60 cm are considered green areas with coefficient 1 (i.e. with 100% of their area). In one ordinance, this coefficient applies to depth of 30-60 cm. In 70 municipalities, the area of green roofs with depth of 30-60 cm is multiplied with a coefficient 0.8 and in one – with 0.4. There is only one municipality considering green roofs with substrate 10-30 cm as a green area under the condition that the substrate is certified and meets certain requirements. Green roofs with substrate depth under 10 cm are not considered a green area in any of the reviewed ordinances.

As one of the main reasons to build a green roof in the densely populated cities in Bulgaria is to meet the legislative requirements for a minimum green area in each property, excluding green roofs with smaller depths from those areas makes them unattractive to the investors. For this reason, an amendment of the legislation is necessary, which will allow green roofs with smaller substrate depths to be considered a green area. A green roof with small substrate depth cannot substitute a green area, however, the difference can be compensated with the use of an appropriate multiplication coefficient.

Green roofs with smaller depths can support many different plant species. A green roof with plants and small shrubs (up to 1m) needs only 15 – 20 cm substrate, and plants and small shrubs below 0.5 m grow on 10-15 cm substrate (Van Lennep, Finn, 2008). There are scientific evidences for the positive effects of green roofs with small substrate depth. Eksi et al. (2017) compared the thermal influence of a green roof with 5 cm substrate and plants of the genus *Sedum* with one with 20 cm substrate and perennial herbaceous plants. Both roofs regulated the temperature of the building. While the 20- cm roof had a more significant impact on the temperature in winter, allowing less heat to leave the building, in summer the 5- cm roof showed higher cooling potential. Castiglia Feitosa et al. (2016) modelled the water retention and efficiency in the reduction of stormwater run-off of green roofs with soil depths of 5, 10, 20, 40, 80 and 160 cm, planted with *Sedum* sp. The results showed 28%, 29%, 32%, 36%, 44% and 60% stormwater retention efficiency, respectively and even higher runoff peak attenuation efficiency. Nardini et al. (2012) studied the effect of green roofs with substrate depths 12 cm/ herbaceous plants and 20 cm/ shrubs and reported reduced thermal load over the rooftop and reduced water runoff effects. Both shrub-vegetated and herbaceous modules intercepted and stored more than 90% rainfall during intense precipitation events. VanWoert et al. (2005) found that roofs with a 4 cm depth of media and a 2% slope absorbed 87% of the runoff. Mentens et al. (2006) analysed 628 data records reported in 18 publications and concluded that rainfall-retention capability on a yearly basis may range from 75% for intensive green roofs (median substrate depth 15 cm) to 45% for extensive green roofs (median substrate depth 10 cm).

An important factor in favour of the green roofs with a smaller depth of the substrate layer is the weight. There is an increase in the positive effects with the increase of the substrate depths; however, substrate depth greater than 10 cm begins to cause structural damages to the roof (Dunnett, Kingbury, 2008).

## Conclusion

Only 75 out of 265 municipalities in Bulgaria have stipulated regulative requirements, under which a green roof can be considered a green area. However, only one of them allows green roofs with substrate depth under 30 cm to be included in the green area (with a coefficient of 0.3). The requirements are unreasonably high and may coercion the investors to forgo the construction of green roofs.

The positive impacts of green roofs with small substrate depth have been proven in many surveys. Positive impacts on the temperature above the roof and inside the building, stormwater retention and runoff peak attenuation are reported in green roofs with a substrate layer thickness of 4 – 5 cm. Although these positive effects increase with the thickness of the substrate layer, thinner green roofs have their advantages. Their construction is possible in most of the buildings without further structural reinforcement of the construction.

In order to obtain the benefits from a green roof without the need for significant strengthening of the buildings, a balance should be found between the weight of the roof and its effects. This balance can be managed by a number of factors but the substrate thickness is an essential one. There is no optimal substrate thickness that can be determined unambiguously. It depends on the load a building can carry and the desired effect of the roof, which depends on the climate in the area.

It is necessary to amend the legislation in Bulgaria to allow the inclusion of green roofs with small substrate thickness in the total green area in urbanised territories. To compensate for the lower efficiency of roofs with a thinner substrate layer the legislation needs to include specific multiplication coefficients, based on the available studies of the efficiency of roofs with different substrate thicknesses.

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